PATENT ABSTRACTS OF JAPAN

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(54) PIEZOELECTRIC CERAMIC COMPOSITION AND PIEZOELECTRIC CERAMIC ELEMENT USING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a piezoelectric ceramic composition useful as a material for piezoelectric ceramic elements such as piezoelectric filter, piezoelectric vibrator and piezoelectric ceramic oscillator exhibiting (≥20%) electromechanical coupling factor kt and (≤45) temperature-changing rate frTC of resonance frequency which are practically usable by improving an electromechanical cou pling factor kt and a temperature-changing rate frTC of resonance frequency at -20°C to 80°C of piezoelectric ceramic composition consisting essentially of SrBi4Ti4O15 and a piezoelectric ceramic element using the above ceramic composition.

SOLUTION: This piezoelectric ceramic composition comprises a main component represented by the general formula SrBi4Ti4O15. In the composition, at least one king of element of Sc and Y is contained in an amount of ≤0.1 mol and >0 based on 1 mol Bi in the main component represented by the above general formula.

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CLAIMS

[Claim(s)]
[Claim 1] The piezoelectric-ceramics constituent characterized by carrying out 0.1-mol or less (0 not being included) content of at least one sort in Sc and Y to Bi in said principal component, and one mol in the piezoelectric-ceramics constituent which uses as a principal component the bismuth stratified compound which consists of Sr, Bi, Ti, and O at least.
[Claim 2] The piezoelectric-ceramics constituent characterized by carrying out 0.1-mol or less (0 not being included) content of at least one sort in Sc and Y to Bi in the principal component expressed with said general formula, and one mol in the piezoelectric-ceramics constituent which consists of a principal component expressed with general formula SrBi4 Ti 4O15.
[Claim 3] It is Mn MnCO3 Piezoelectric-ceramics constituent according to claim 1 or 2 characterized by converting and carrying out content 1.5 or less (0 not being included) % of the weight.
[Claim 4] The piezo-electric ceramic component containing the electrode formed in the piezoelectric ceramics which consist of a piezoelectric-ceramics constituent according to claim 1 to 3, and said piezoelectric ceramics.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the piezo-electric ceramic component using a piezoelectric-ceramics constituent and it useful as ingredients, such as piezo-electric ceramic components, such as a piezo-electric ceramic filter, a piezo-electric ceramic radiator, and a piezo-electric ceramic vibrator, especially about the piezo-electric ceramic component which used a piezoelectric-ceramics constituent and it, for example.
[0002]
[Description of the Prior Art] The piezoelectric-ceramics constituent which uses titanic-acid lead zirconate ($Pb(Ti_x Zr_{1-x})O_3$) or lead titanate ($PbTiO_3$) as a principal component is conventionally used widely as a piezoelectric-ceramics constituent used for piezo-electric ceramic components, such as a piezo-electric ceramic filter, a piezo-electric ceramic radiator, and a piezo-electric ceramic vibrator. However, in the piezoelectric-ceramics constituent which uses titanic-acid lead zirconate or lead titanate as a principal component, since lead was contained so much during the presentation, there was a problem that the homogeneity of a product fell in a manufacture process for evaporation of a plumbic acid ghost. In order to prevent the homogeneous fall of the product by evaporation of the plumbic acid ghost in a manufacture process, or lead is not included at all during a presentation, the piezoelectric-ceramics constituent only containing small quantity is desirable. In the piezoelectric-ceramics [this] constituent which carry out a pair and use bismuth stratified compounds, such as $SrBi_4Ti_4O_{15}$, as a principal component, since a plumbic acid ghost is not contained during the presentation, the above problems are not produced.
[0003]
[Problem(s) to be Solved by the Invention] In the piezoelectric-ceramics constituent which uses $SrBi_4Ti_4O_{15}$ etc. as a principal component, since the rate frTC of a temperature change with a resonance frequency of -20 to 80 degrees C [an electromechanical coupling coefficient kt indicates small below the titanic-acid lead zirconate or lead titanate used for piezo-electric ceramic components, such as a piezo-electric ceramic filter, a piezo-electric ceramic radiator, and a piezo-electric ceramic vibrator, from the former to be compared with the piezoelectric-ceramics constituent used as a principal component] is large, practical use has come [however,] to be presented widely.
frTC=(fr(max)-fr (min))/(fr (20 degrees C), 100)
fr(max): Minimum resonance frequency fr(20 degrees C):20 degree C [in the resonance frequency fr (min):-20 degree C to 80 degrees C No.1 temperature requirement in a -20 degree C to 80 degrees C temperature requirement] resonance frequency [0004] So, the main purpose of this invention improves the rate frTC of a temperature change with an electromechanical coupling coefficient [of the piezoelectric-ceramics constituent which uses $SrBi_4Ti_4O_{15}$ as a principal component / kt], and a resonance frequency of -20 to 80 degrees C. The piezo-electric ceramic filter in which the rate frTC of a temperature change (45 or less) of the electromechanical coupling coefficient kt (20% or more) of extent with which practical use can be presented, and resonance frequency is shown, It is offering the piezo-electric ceramic component using a piezoelectric-ceramics constituent and it useful as ingredients, such as piezo-electric ceramic components, such as a piezo-electric ceramic radiator and a piezo-electric ceramic vibrator.
[0005]

[Means for Solving the Problem] The piezoelectric-ceramics constituent concerning this invention is a piezoelectric-ceramics constituent characterized by carrying out 0.1-mol or less (0 not being included) content of at least one sort in Sc and Y to Bi in said principal component, and one mol in the piezoelectric-ceramics constituent which uses as a principal component the bismuth stratified compound which consists of Sr, Bi, Ti, and O at least. Moreover, the piezoelectric-ceramics constituent concerning this invention is a piezoelectric-ceramics constituent characterized by carrying out 0.1-mol or less (0 not being included) content of at least one sort in Sc and Y to Bi in the principal component expressed with that general formula, and one mol in the piezoelectric-ceramics constituent which consists of a principal component expressed with general formula SrBi4 Ti 4O15. With the piezoelectric-ceramics constituent concerning this invention, Mn is MnCO3. Content may be converted and carried out 1.5 or less (0 is not included) % of the weight. The piezo-electric ceramic component concerning this invention is a piezo-electric ceramic component containing the piezoelectric ceramics which consist of a piezoelectric-ceramics constituent concerning this invention, and the electrode formed in piezoelectric ceramics. In addition, although the principal component in the piezoelectric-ceramics constituent concerning this invention is expressed with general formula SrBi4 Ti 4O15, the mole ratio of each element may have a gap of some.

[0006] In the piezoelectric-ceramics constituent concerning this invention, to Bi and one mol, when [than this] more, the fall of an electromechanical coupling coefficient kt is seen, and the practical electromechanical coupling coefficient kt is not obtained, or the content of Sc and Y was set to 0.1 mols or less (0 is not included), because the porcelain which can be polarized was not obtained. Moreover, although Takahashi and others shows clearly that an electromechanical coupling coefficient kt improves by converting Mn into the piezoelectric-ceramics constituent which uses SrBi4 Ti 4O15 as a principal component in Japanese Patent Application No. No. 85292 [48 to] at MnO, and containing 0.005 to 0.7% of the weight Also in the piezoelectric-ceramics constituent which carried out optimum dose content of Mn, the effectiveness of the invention in this application is effective in the piezoelectric-ceramics constituent used as such a piezoelectric-ceramics constituent, i.e., a principal component, and a useful piezoelectric-ceramics constituent with the small rate frTC of a temperature change of resonance frequency with a still larger and electromechanical coupling coefficient kt is obtained. It sets to invention concerning claim 3, and is the content of Mn MnCO3 When [than this] more, it converted and because the porcelain which can be polarized was not obtained, could be 1.5 or less (0 is not included) % of the weight. Moreover, since the rate frTC of a temperature change of resonance frequency becomes small especially in addition to improvement in an electromechanical coupling coefficient kt when Y is chosen among the content elements of Sc and Y, the still more useful piezoelectric-ceramics constituent as ingredients, such as piezo-electric ceramic components, such as a piezo-electric ceramic filter, a piezo-electric ceramic radiator, and a piezo-electric ceramic vibrator, is obtained especially, for example.

[0007] The above-mentioned purpose of this invention, the other purposes, the description, and an advantage will become still clearer from detailed explanation of the gestalt of implementation of the following invention performed with reference to a drawing.

[0008]

[Embodiment of the Invention] (Example) First, as a start raw material, SrCO3, Bi 2O3, TiO2, Sc 2O3, and Y2 O3 are prepared, and it is presentation (Sr1-x Mx) Bi4 Ti4O15 +y % of the weight MnCO3 (M is either Sc and Y.) about these. And MnCO3 0<=x<=0.45, 0<=y<=1.6. It ****(ed) so that it might become, and wet blending was carried out for about 4 hours using the ball mill, and mixture was obtained. After drying the obtained mixture, temporary quenching was carried out at 700-900 degrees C, and the temporary-quenching object was obtained. And after carrying out coarse grinding of this temporary-quenching object, wet grinding of the organic binder was carried out for 4 hours using optimum dose, in addition a ball mill, and grain refining was performed through the screen of 40 meshes. Next, it is this 1000kg/cm2 Disc-like porcelain was obtained by casting by the pressure to a disk with a diameter [of 12.5mm], and a thickness of 2mm, and calcinating this at 1150-1250 degrees C in atmospheric air. After having applied the silver paste to the front face (both principal planes) of this porcelain by the usual approach, baking on it and forming a silver electrode

in it, the direct current voltage of 5-10kV/mm was impressed for 10 - 30 minutes in 150-200-degree C insulating oil, polarization processing was performed, and piezoelectric ceramics (sample) were obtained. And the rate frTC of a temperature change of an electromechanical coupling coefficient kt and resonance frequency was measured about the obtained sample. The result is shown in Table 1. In addition, it is indicated in Table 1 also as the symbol of element of M in the presentation of each sample, and the numeric value of x and y. Note that it is equivalent to the content (mol) of M to Bi and one mol, 1/4, x/4 [i.e.,], in the above-mentioned empirical formula of x, in Table 1.
[0009]
[Table 1]

試料 No	M	x	y (wt%)	k t (%)	f r T C (ppm/℃)
1*	−	0	0	12	80
2	Y	0.1	0	24	35
3	Y	0.4	0	24	29
4*	Y	0.45	0	分極不可	−
5	Y	0.4	1.5	21	25
6*	Y	0.45	1.5	分極不可	−
7*	Y	0.4	1.6	分極不可	−
8	Sc	0.1	1	21	45
9	Sc	0.4	1	24	40
10*	Sc	0.45	1	分極不可	−

Sample * mark of the No. column shows that this invention of that sample is out of range.
[0010] Since electromechanical coupling coefficients kt are in 20% or more and practical use level and the rate frTC of a temperature change of resonance frequency is all in 45 or less and practical use level about each sample concerning the example of this invention as shown in Table 1, it is especially clear that it is a piezoelectric-ceramics constituent useful as ingredients, such as piezo-electric ceramic components, such as a piezo-electric ceramic filter, a piezo-electric ceramic radiator, and a piezo-electric ceramic vibrator, for example. Moreover, in sample No.2 of the example of this invention, and 3 and 5, as shown in Table 1, when Y is included, it is clear that useful piezoelectric ceramics with the especially small rate frTC of a temperature change of resonance frequency are obtained.
[0011] In addition, the piezoelectric-ceramics constituent concerning this invention is not limited to the presentation of the above-mentioned example, and if it is within the limits of the summary of invention, it is effective.
[0012] Moreover, although the rate frTC of a temperature change of an electromechanical coupling coefficient kt and resonance frequency showed the example about the thickness longitudinal oscillation of a disc-like piezo-electric ceramic vibrator in the above-mentioned example The effectiveness of the invention in this application is not limited to the thickness longitudinal oscillation of a disc-like piezo-electric ceramic vibrator. The higher harmonic of thickness skid vibration or thickness longitudinal oscillation etc. is effective like the case of thickness longitudinal oscillation also in other oscillation modes especially used for a piezo-electric ceramic filter, a piezo-electric ceramic radiator, etc. as other piezo-electric ceramic components, for example.
[0013] Drawing 1 is the perspective view showing an example of the piezo-electric ceramic vibrator concerning this invention, and drawing 2 is that sectional view solution Fig. The piezo-electric ceramic vibrator 10 shown in drawing 1 and drawing 2 contains the rectangular parallelepiped-like piezoelectric ceramics 12. Piezoelectric ceramics 12 contain the piezoelectric-ceramics layers 12a and 12b of two sheets. These piezoelectric-ceramics layers 12a and 12b consist of a piezoelectric-ceramics constituent concerning this above-mentioned invention, and the laminating of them is carried out and they are formed in one. Moreover, as the arrow head of drawing 2 shows, polarization of these piezoelectric-ceramics layers 12a and 12b is carried out in the same thickness direction.
[0014] Among the piezoelectric-ceramics layers 12a and 12b, circular vibrating electrode 14a is

formed in the center, for example, and drawer electrode 16a of T typeface is formed covering the end side of piezoelectric ceramics 12 from vibrating electrode 14a. Moreover, circular vibrating electrode 14b is formed in the center, for example, and drawer electrode 16b of T typeface is formed in the front face of piezoelectric-ceramics layer 12a covering the other end side of piezoelectric ceramics 12 from vibrating electrode 14b. Furthermore, circular vibrating electrode 14c is formed in the center, for example, and drawer electrode 16c of T typeface is formed in the front face of piezoelectric-ceramics layer 12b covering the other end side of piezoelectric ceramics 12 from vibrating electrode 14c.

[0015] And one external terminal 20a is connected to drawer electrode 16a through lead-wire 18a, and external terminal 20b of another side is connected to the drawer electrodes 16b and 16c through another lead-wire 18b.

[0016] In addition, this invention is applied to other piezo-electric ceramic components, such as piezo-electric ceramic vibrators other than above-mentioned piezo-electric ceramic vibrator 10, a piezo-electric ceramic filter, and a piezo-electric ceramic radiator.

[0017]

[Effect of the Invention] According to this invention, it is the piezoelectric-ceramics constituent which uses SrBi4 Ti 4O15 as a principal component, and an electromechanical coupling coefficient kt is improved to 20% or more, and the rate of a temperature change of resonance frequency is improved by 45 or less, and the piezo-electric ceramic component using a piezoelectric-ceramics constituent and it useful as ingredients, such as piezo-electric ceramic components, such as a piezo-electric ceramic filter, a piezo-electric ceramic radiator, and a piezo-electric ceramic vibrator, is obtained especially, for example.

[Translation done.]

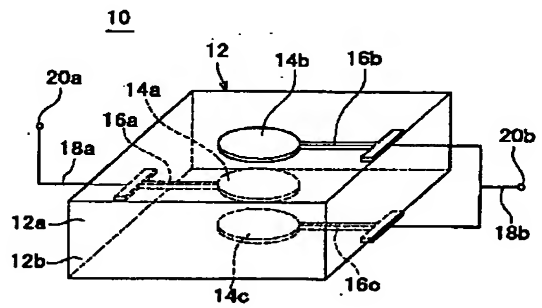
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective view showing an example of the piezo-electric ceramic vibrator concerning this invention.
[Drawing 2] It is the sectional view solution Fig. of the piezo-electric ceramic vibrator shown in drawing 1 .
[Description of Notations]
10 Piezo-electric Ceramic Vibrator
12 Piezoelectric Ceramics
12a, 12b Piezoelectric-ceramics layer
14a, 14b, 14c Vibrating electrode
16a, 16b, 16c Drawer electrode
18a, 18b Lead wire
20a, 20b External terminal

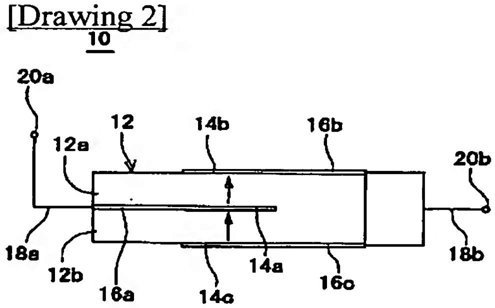
[Translation done.]

DRAWINGS

[Drawing 1]



[Drawing 2]



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PROBLEM TO BE SOLVED: To provide a piezoelectric ceramic composition useful as a material for piezoelectric ceramic elements such as piezoelectric filter, piezoelectric vibrator and piezoelectric ceramic oscillator exhibiting (≥20%) electromechanical coupling factor kt and (≤45) temperature-changing rate frTC of resonance frequency which are practically usable by improving an electromechanical cou pling factor kt and a temperature-changing rate frTC of resonance frequency at -20° C to 80° C of piezoelectric ceramic composition consisting essentially of SrBi4Ti4O15 and a piezoelectric ceramic element using the above ceramic composition.
SOLUTION: This piezoelectric ceramic composition comprises a main component represented by the general formula SrBi4Ti4O15. In the composition, at least one king of element of Sc and Y is contained in an amount of ≤ 0.1 mol and >0 based on 1 mol Bi in the main component represented by the above general formula.

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41/187		41/18	１０１Ｊ

審査請求　未請求　請求項の数４　ＯＬ　（全４頁）

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最終頁に続く

(54)【発明の名称】　圧電磁器組成物およびそれを用いた圧電セラミック素子

(57)【要約】
【課題】　$SrBi_4Ti_4O_{15}$ を主成分とする圧電磁器組成物の電気機械結合係数ｋｔおよび－２０℃から８０℃の共振周波数の温度変化率ｆｒＴＣを改善し、実用に供しうる程度の電気機械結合係数ｋｔ（２０％以上）および共振周波数の温度変化率ｆｒＴＣ（４５以下）を示す圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子などの材料として有用な圧電磁器組成物およびそれを用いた圧電セラミック素子を提供する。
【解決手段】　圧電磁器組成物は、一般式 $SrBi_4Ti_4O_{15}$ で表される主成分からなる圧電磁器組成物において、ＳｃおよびＹのうちの少なくとも１種をその一般式で表される主成分中のＢｉ、１ｍｏｌに対して０．１ｍｏｌ以下（０を含まない）含有することを特徴とする。

【特許請求の範囲】

【請求項１】　少なくともＳｒ、Ｂｉ、Ｔｉ、Ｏからなるビスマス層状化合物を主成分とする圧電磁器組成物において、ＳｃおよびＹのうちの少なくとも１種を前記主成分中のＢｉ、１ｍｏｌに対して０．１ｍｏｌ以下（０を含まない）含有することを特徴とする、圧電磁器組成物。

【請求項２】　一般式$SrBi_4Ti_4O_{15}$で表される主成分からなる圧電磁器組成物において、ＳｃおよびＹのうちの少なくとも１種を前記一般式で表される主成分中のＢｉ、１ｍｏｌに対して０．１ｍｏｌ以下（０を含まない）含有することを特徴とする、圧電磁器組成物。

【請求項３】　ＭｎをＭｎCO_3に換算して１．５重量％以下（０を含まない）含有することを特徴とする、請求項１または請求項２に記載の圧電磁器組成物。

【請求項４】　請求項１ないし請求項３のいずれかに記載の圧電磁器組成物からなる圧電磁器、および前記圧電磁器に形成される電極を含む、圧電セラミック素子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】この発明は圧電磁器組成物およびそれを用いた圧電セラミック素子に関し、特にたとえば、圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子などの材料として有用な圧電磁器組成物およびそれを用いた圧電セラミック素子に関する。

【０００２】

【従来の技術】圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子に用いられる圧電磁器組成物として、従来、チタン酸ジルコン酸鉛（$Pb(Ti_xZr_{1-x})O_3$）またはチタン酸鉛（$PbTiO_3$）を主成分とする圧電磁器組成物が広く用いられている。しかしながら、チタン酸ジルコン酸鉛またはチタン酸鉛を主成分とする圧電磁器組成物では、その組成中に鉛を多量に含有するため、製造過程において鉛酸化物の蒸発のため製品の均一性が低下するという問題があった。製造過程における鉛酸化物の蒸発による製品の均一性の低下を防止するためには、組成中に鉛をまったく含まないまたは少量のみ含む圧電磁器組成物が好ましい。これ対して、$SrBi_4Ti_4O_{15}$などのビスマス層状化合物を主成分とする圧電磁器組成物では、その組成中に鉛酸化物を含有しないため、上記のような問題は生じない。

【０００３】

【発明が解決しようとする課題】しかしながら、$SrBi_4Ti_4O_{15}$などを主成分とする圧電磁器組成物では、従来から圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子に用いられているチタン酸ジルコン酸鉛またはチタン酸鉛を主成分とする圧電磁器組成物に比べて、電気機械結合係数ｋｔが小さくかつ以下に示す－２０℃から８０℃の共振周波数の温度変化率ｆｒＴＣが大きいため、広く実用に供されるに至っていない。

$frTC=(fr(max)-fr(min))/(fr(20℃)\cdot 100)$

ｆｒ（max）：－２０℃から８０℃の温度範囲において最高の共振周波数

ｆｒ（min）：－２０℃から８０℃の温度範囲において最低の共振周波数

ｆｒ（20℃）：２０℃での共振周波数

【０００４】それゆえに、この発明の主たる目的は、$SrBi_4Ti_4O_{15}$を主成分とする圧電磁器組成物の電気機械結合係数ｋｔおよび－２０℃から８０℃の共振周波数の温度変化率ｆｒＴＣを改善し、実用に供しうる程度の電気機械結合係数ｋｔ（２０％以上）および共振周波数の温度変化率ｆｒＴＣ（４５以下）を示す圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子などの材料として有用な圧電磁器組成物およびそれを用いた圧電セラミック素子を提供することである。

【０００５】

【課題を解決するための手段】この発明にかかる圧電磁器組成物は、少なくともＳｒ、Ｂｉ、Ｔｉ、Ｏからなるビスマス層状化合物を主成分とする圧電磁器組成物において、ＳｃおよびＹのうちの少なくとも１種を前記主成分中のＢｉ、１ｍｏｌに対して０．１ｍｏｌ以下（０を含まない）含有することを特徴とする、圧電磁器組成物である。また、この発明にかかる圧電磁器組成物は、一般式$SrBi_4Ti_4O_{15}$で表される主成分からなる圧電磁器組成物において、ＳｃおよびＹのうちの少なくとも１種をその一般式で表される主成分中のＢｉ、１ｍｏｌに対して０．１ｍｏｌ以下（０を含まない）含有することを特徴とする、圧電磁器組成物である。この発明にかかる圧電磁器組成物では、ＭｎがＭｎCO_3に換算して１．５重量％以下（０を含まない）含有されてもよい。この発明にかかる圧電セラミック素子は、この発明にかかる圧電磁器組成物からなる圧電磁器と、圧電磁器に形成される電極とを含む、圧電セラミック素子である。なお、この発明にかかる圧電磁器組成物における主成分は一般式$SrBi_4Ti_4O_{15}$で表されるが、それぞれの元素のモル比は多少のずれがあってもかまわない。

【０００６】この発明にかかる圧電磁器組成物において、ＳｃおよびＹの含有量をＢｉ、１ｍｏｌに対して０．１ｍｏｌ以下（０を含まない）としたのは、これより多い場合には、電気機械結合係数ｋｔの低下がみられ、実用的な電気機械結合係数ｋｔが得られない、または、分極可能な磁器が得られないためである。また、高橋らは、特願昭４８－８５２９２号において、$SrBi_4Ti_4O_{15}$を主成分とする圧電磁器組成物にＭｎをＭ

ｎＯに換算して０．００５～０．７重量％含有することにより、電気機械結合係数ｋｔが向上することを明らかにしているが、このような圧電磁器組成物すなわち主成分となる圧電磁器組成物にＭｎを適量含有した圧電磁器組成物においても、本願発明の効果は有効であり、電気機械結合係数ｋｔがさらに大きくかつ共振周波数の温度変化率ｆｒＴＣが小さい有用な圧電磁器組成物が得られる。請求項３にかかる発明において、Ｍｎの含有量を$MnCO_3$に換算して１．５重量％以下（０を含まない）としたのは、これより多い場合には分極可能な磁器が得られないためである。また、ＳｃおよびＹの含有元素のうちＹを選択した場合には、電気機械結合係数ｋｔの向上に加え、共振周波数の温度変化率ｆｒＴＣが特に小さくなるため、特にたとえば、圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子などの材料としてさらに有用な圧電磁器組成物が得られる。

【０００７】この発明の上述の目的、その他の目的、特徴および利点は、図面を参照して行う以下の発明の実施の形態の詳細な説明から一層明らかとなろう。

【０００８】

【発明の実施の形態】（実施例）まず、出発原料として、$SrCO_3$、Bi_2O_3、TiO_2、Sc_2O_3、Y_2O_3および$MnCO_3$を用意し、これらを組成$(Sr_{1-x}M_x)Bi_4Ti_4O_{15}$＋ｙ重量％$MnCO_3$（Ｍは、ＳｃおよびＹのいずれか。０≦ｘ≦０．４５、０≦ｙ≦１．６。）となるように秤取して、ボールミルを用いて約４時間湿式混合して、混合物を得た。得られた混合物を乾燥した後、７００～９００℃で仮焼して、仮焼物を得た。それから、この仮焼物を粗粉砕した後、有機バインダを適量加えてボールミルを用いて４時間湿式粉砕し、４０メッシュのふるいを通して粒度調整を行った。次に、これを１０００ｋｇ／cm^2の圧力で直径１２．５ｍｍ、厚さ２ｍｍの円板に成型し、これを大気中で１１５０～１２５０℃で焼成することによって、円板状の磁器を得た。この磁器の表面（両主面）に、通常の方法により銀ペーストを塗布し焼付けて銀電極を形成した後、１５０～２００℃の絶縁オイル中で５～１０ｋＶ／ｍｍの直流電圧を１０～３０分間印加して分極処理を施し、圧電磁器（試料）を得た。そして、得られた試料について、電気機械結合係数ｋｔおよび共振周波数の温度変化率ｆｒＴＣを測定した。その結果を表１に示す。なお、表１には、各試料の組成におけるＭの元素記号と、ｘおよびｙの数値とも示す。表１において、上記の組成式中のｘの１／４すなわちｘ／４がＢｉ、１ｍｏｌに対してのＭの含有量（ｍｏｌ）に相当することに注意されたい。

【０００９】

【表１】

試料 No.	M	x	y (wt%)	kt (%)	frTC (ppm/℃)
1*	−	0	0	12	80
2	Y	0.1	0	24	35
3	Y	0.4	0	24	29
4*	Y	0.45	0	分極不可	−
5	Y	0.4	1.5	21	25
6*	Y	0.45	1.5	分極不可	−
7*	Y	0.4	1.6	分極不可	−
8	Sc	0.1	1	21	45
9	Sc	0.4	1	24	40
10*	Sc	0.45	1	分極不可	−

試料 No.欄の＊印はその試料がこの発明の範囲外であることを示す。

【００１０】表１に示すように、この発明の実施例にかかる各試料については、いずれも、電気機械結合係数ｋｔが２０％以上と実用レベルにありかつ共振周波数の温度変化率ｆｒＴＣが４５以下と実用レベルにあることから、特にたとえば、圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子などの材料として有用な圧電磁器組成物であることが明らかである。また、表１に示すように、Ｙを含む場合、すなわち、この発明の実施例の試料No.２、３および５においては、共振周波数の温度変化率ｆｒＴＣが特に小さい有用な圧電磁器が得られることが明らかである。

【００１１】なお、この発明にかかる圧電磁器組成物は上記の実施例の組成に限定されるものではなく、発明の要旨の範囲内であれば有効である。

【００１２】また、上述の実施例では電気機械結合係数ｋｔおよび共振周波数の温度変化率ｆｒＴＣは円板状の圧電セラミック振動子の厚み縦振動についての例を示したが、本願発明の効果は、円板状の圧電セラミック振動子の厚み縦振動に限定されず、厚みすべり振動や厚み縦振動の高調波など、他の圧電セラミック素子として特にたとえば圧電セラミックフィルタや圧電セラミック発振

子などに利用される他の振動モードにおいても、厚み縦振動の場合と同様に有効である。

【００１３】図１はこの発明にかかる圧電セラミック振動子の一例を示す斜視図であり、図２はその断面図解図である。図１および図２に示す圧電セラミック振動子１０は、たとえば直方体状の圧電磁器１２を含む。圧電磁器１２は、２枚の圧電磁器層１２ａおよび１２ｂを含む。これらの圧電磁器層１２ａおよび１２ｂは、上述のこの発明にかかる圧電磁器組成物からなり、積層されかつ一体的に形成される。また、これらの圧電磁器層１２ａおよび１２ｂは、図２の矢印で示すように、同じ厚み方向に分極されている。

【００１４】圧電磁器層１２ａおよび１２ｂの間には、その中央にたとえば円形の振動電極１４ａが形成され、その振動電極１４ａから圧電磁器１２の一端面にわたってたとえばＴ字形の引出電極１６ａが形成される。また、圧電磁器層１２ａの表面には、その中央にたとえば円形の振動電極１４ｂが形成され、その振動電極１４ｂから圧電磁器１２の他端面にわたってたとえばＴ字形の引出電極１６ｂが形成される。さらに、圧電磁器層１２ｂの表面には、その中央にたとえば円形の振動電極１４ｃが形成され、その振動電極１４ｃから圧電磁器１２の他端面にわたってたとえばＴ字形の引出電極１６ｃが形成される。

【００１５】そして、引出電極１６ａにはリード線１８ａを介して一方の外部端子２０ａが接続され、引出電極１６ｂおよび１６ｃには別のリード線１８ｂを介して他＊＊方の外部端子２０ｂが接続される。

【００１６】なお、この発明は、上述の圧電セラミック振動子１０以外の圧電セラミック振動子、圧電セラミックフィルタおよび圧電セラミック発振子などの他の圧電セラミック素子にも適用される。

【００１７】

【発明の効果】この発明によれば、$SrBi_4Ti_4O_{15}$ を主成分とする圧電磁器組成物であって、電気機械結合係数ｋｔが２０％以上に改善されかつ共振周波数の温度変化率が４５以下に改善され、特にたとえば圧電セラミックフィルタ、圧電セラミック発振子および圧電セラミック振動子などの圧電セラミック素子などの材料として有用な圧電磁器組成物およびそれを用いた圧電セラミック素子が得られる。

【図面の簡単な説明】

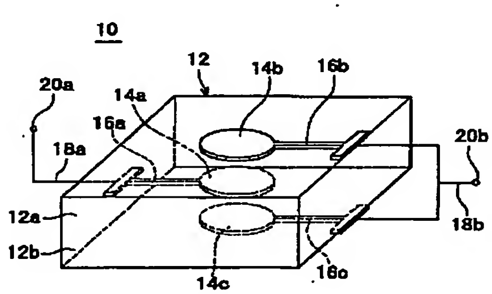
【図１】この発明にかかる圧電セラミック振動子の一例を示す斜視図である。

【図２】図１に示す圧電セラミック振動子の断面図解図である。

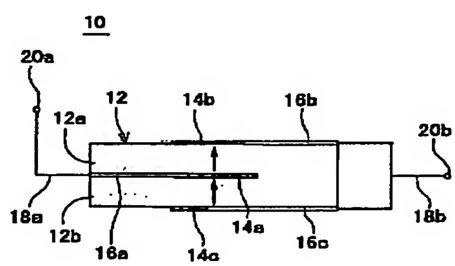
【符号の説明】

１０　圧電セラミック振動子
１２　圧電磁器
１２ａ、１２ｂ　圧電磁器層
１４ａ、１４ｂ、１４ｃ　振動電極
１６ａ、１６ｂ、１６ｃ　引出電極
１８ａ、１８ｂ　リード線
２０ａ、２０ｂ　外部端子

【図１】



【図２】



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